

The benchmarks used in the empirical study are the index portfolio, the market-value weighted portfolio and the naive portfolio. As expected, the optimized portfolios resulted in lower Omega values and lower cost levels than investing in the benchmark portfolios in in-sample results. In the out-sample, we observe a drastically different returns distribution but the optimized portfolios still outperform the benchmark portfolios.

### DEH.3 ANGEL: A hybrid metaheuristic for continuous engineering optimization

*Presenter:* Aniko Csebfalvi (University of Pecs)

*Coauthors:* Gyorgy Csebfalvi

Most structural engineering optimisation problems are highly nonlinear and nonconvex. The problem is typically large, and the evaluation of the functions and gradients is expensive due to their implicit dependence on design variables. The traditional engineering optimisation algorithms are based on nonlinear programming methods that require substantial gradient information and usually seek to improve the solution in the neighbourhood of a starting point. Many real-world engineering optimisation problems, however, are very complex in nature and quite difficult to solve using these algorithms. If there is more than one local optimum in the problem, the result may depend on the selection of an initial point, and the obtained optimal solution may not necessarily be the global optimum. The computational drawbacks of existing numerical methods have forced researchers to rely on metaheuristic algorithms based on simulations to solve engineering optimisation problems. The common factor in metaheuristic algorithms is that they combine rules and randomness to imitate natural phenomena. This paper describes a hybrid metaheuristic ANGEL for engineering optimisation problems with continuous design variables. ANGEL combines ant colony optimisation (ACO), genetic algorithms (GA), and local search strategies (LS). In the presented algorithm ACO and GA search alternately and cooperatively in the solution space. The powerful LS algorithm, which is based on the local linearisation of the constraint set, is applied to yield a better feasible or less infeasible solution when ACO or GA obtains a solution. The presented algorithm is a slightly modified and simplified continuous version of the original discrete ANGEL algorithm developed by Tseng and Chen (2006) for the resource-constrained project scheduling problem. The presented continuous ANGEL algorithm can be easily adopted for various types of optimisation problems including the traditional explicit function minimization problems. According to the systematic simplification, the hybrid algorithm is based on only three operators: random selection (ACO + GA), random perturbation (ACO), and random combination (GA). In the ANGEL algorithm the traditional mutation operator is replaced by the local search procedure as a form of mutation. That is, rather than introducing small random perturbations into the offspring solution, a gradient based local search is applied to improve the solution until a local optimum is reached. The main procedure of ANGEL follows the repetition of these two steps: (1) ACO with LS and (2) GA with LS. In other words, firstly ANGEL generates an initial population, after that, in an iterative process ACO and GE search alternately and cooperatively on the current solution set. The initial population is a totally random set. The random perturbation and random combination procedures which are based on the normal distribution, call the random selection function, to select a more or less good solution from the current population using the well-known discrete inverse method. The higher the fitness values of a solution, the higher the chance that it will be selected by the function. Our fitness function is based on the following assumptions: (1) Any feasible solution is preferred to any infeasible solution. (2) Between two feasible solutions, the one having better objective function value is preferred. (3) Between two infeasible solutions, the one having smaller constraint violations is preferred. The random perturbation procedure uses the continuous inverse method to generate a new solution from the old one. The random combination procedure generates an offspring solution from the selected mother and father solutions. Using the continuous inverse method, the offspring solution is generated from the combined distribution, where the combined distribution is the weighted sum of the parent's distributions. The two procedures are controlled by the standard deviation. The higher the standard deviation, the higher the variability of the searching process is. According to the progress of the searching process the variability is decreasing step by step. In other words, the 'freedom of diversification' is decreasing but the 'freedom of intensification' is increasing. The procedures use a uniform random number generator in the inverse method. We have to mention, that in our algorithm in the GE phase, an offspring not necessarily will be the member of the current population, and a parent not necessarily will die after mating. The reason is straightforward, because our algorithm uses very simple rule: If the current design is better than the worst solution of the current population than the worst one will be replaced by the better one. The ANGEL algorithm is tested for a wide range of benchmark problems. Validation results for two examples, which are manageable within the scope of this paper, are presented herein. The first problem is a challenging explicit function minimisation problem with two variables and two inequality constraints and four boundary conditions. The feasible region of the problem is a very narrow crescent-shaped region (approximately 0.7 % of the total search space) with the optimal solution lying on a constraint. The second problem is a well-known 10-bar truss with 10 independent design variables, 20 boundary conditions

and 36 implicit constraints. The problem has several local optimum solutions and the global optimum of the problem is unknown. These examples have been previously solved using a variety of other techniques, which is useful to show the validity and effectiveness of ANGEL. Numerical results show that ANGEL can be more efficient and robust than the conventional gradient based deterministic or the traditional population based heuristic methods in solving explicit (implicit) optimisation problems. ANGEL produces highly competitive results in significantly shorter run-times than the previously described approaches.

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DC2 - Room 342

Organizer

Chair

DC Programming and DCA : Algorithms and Applications II

*Le Thi Hoai An, Pham Dinh Tao*

*Pham Dinh Tao*

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#### DC2.1 Feature Selection via DC Programming and DCA

*Presenter:* Le Hoai Minh (Metz University)

*Coauthors:* Le Thi Hoai An, Nguyen Van Vinh, Pham Dinh Tao

Feature selection consists of choosing a subset of available features that capture the relevant properties of the data. In the supervised pattern classification, a good choice of features is a key for building compact and accurate classifiers. In this paper we introduce a novel feature selection method using the zero-norm  $l_0$  in the context of support vector machines (SVMs). Discontinuity at the origin for  $l_0$  makes the solution of the corresponding optimization problem difficult. To overcome this drawback we use a robust DC (Difference of Convex functions) programming approach which is a general framework for non-convex continuous optimisation. We consider a continuous approximation to  $l_0$  in an appropriate way such that the resulting problem can be formulated in terms of a DC program. Our DCA (DC Algorithm) requires the solution of one linear program at each iteration. Preliminary computational experiments on some real-world data sets show that the proposed method is promising for feature selection and more efficient than some existing approaches including SFV (Feature Selection concave).

#### DC2.2 DC Programming approach and DCA for Standard Quadratic Programs

*Presenter:* Nguyen Canh Nam (Technical University of Denmark)

*Coauthors:* Pham Dinh Tao, Le Thi Hoai An

The standard quadratic program (QPS) is minimizing a quadratic function over the standard simplex. QPS can be used to formulate combinatorial problems such as the maximum stable set problem, and also arises in global optimization algorithms for general quadratic programming when the search space is partitioned using simplices. We investigate a local approach based on the DC (Difference of Convex functions) programming and DCA (DC Algorithms) - which are descent methods without linesearch- for solving (QPS) Despite its local character, we observe that in practice DCA provides quite often global solutions of nonconvex quadratic programs. Evidently, the qualities of DCA (speed of convergence, robustness, efficiency, globality of computed solutions, ...) of DCA heavily depend on the DC decomposition and the starting point. In this work we propose an appropriate DC decomposition which makes the computations when applying DCA to (QPS) are explicit. Moreover a good starting point which is the global optimal solution of the trust region problem is also investigated. To check globality solutions computed by DCA or to find new better solution for restarting DCA, we develop a combination of DCA and Branch-and-Bound (BB) technique suitably adapted to the structure of (QPS). BB will rely on an explicit convex minority of  $f$  on the simplex. Computational experiments are reported which show the effective performance of our approach.

#### DC2.3 Stochastic Optimization and Control Applied to Control the Uncertainties in Departing Stage of Traffic Flow

*Presenter:* Trung-Tuyen Hoang (INSA-Rouen)

*Coauthors:* Pham Dinh Tao, Ly Henri

Most flights are subjected to operational uncertainties due to the quality of weather forecast, technical and logistics issues at airport. Therefore, improving flight punctuality is an essential element to the smooth Air Traffic Flow Management (ATFM) operations. Traditional ATFM system is flight-based, i.e. the schedule is established based on discrete events and a deterministic approach. Because of the operational uncertainties, gaps often exist between scheduled and executed traffic. This leads to sub-optimal use of airport resources